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Fe³⁺ coordination induced selective fluorination of aramid fiber to suppress surface chain scission behavior and improve surface polarity

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Abstract: The selective fluorination of aramid fiber surface was reported by Fe³⁺ coordination on the benzimidazole unit. After the coordination, both of the two parts in benzimidazole unit, benzene ring and imidazole ring, take priority in the reaction with the fluorine gas, while the reaction with the amide bond is restrained. In this way, selective fluorination on benzimidazole unit is achieved, with the surface polarity increasing and chain scission behavior suppressed simultaneously. What's more, the increased surface polarity enables the improvement of the interfacial shear strength by 24%, compared with that in a traditional fluorination way. In all, the study offers an easy and effective strategy for the regulation and controlling of direct fluorination reaction, and it provides a guideline for further adjustment of the reaction mechanism to meet the requirement in other applications.

Keywords: Direct fluorination; Coordination; Aramid fiber; Chain scission; Interfacial properties

Introduction

Due to its superior tensile-strength-to-weight ratio and excellent thermal stability, aramid fiber is widely manufactured in many countries and extensively utilized in engineering field. Structural composite materials made of aramid fiber-reinforced plastics are widely used in aviation and space engineering[1, 2]. However, there are still several problems that aramid fiber is facing and demanding prompt solution, including the poor interfacial properties with resin composite, poor compression strength and weak UV resistance[3-7]. Among them, the study on the improvement of interfacial properties has always been the most concerned research direction, since interfacial adhesion of the composite guarantees the load transferring from the resin matrix to the fiber, which greatly affects the composite properties.

Commonly, aramid fiber possesses a chemically inert surface, and numerous methods have been reported for surface modification of aramid fiber to improve the interfacial properties, such as chemical oxidation, layer by layer coating, plasma and gamma irradiation and acid/basic treatment etc [5, 8-11]. Recently, direct fluorination, as an effective method of surface modification, has received great attention by its versatile superiority [12-15]. It provides a simple and fast approach to greatly change the surface structure of aramid fiber, which is suitable for the practical application in the large-scale production [16-18]. Lee et al reported that the fluorinated fiber become more hydrophobic and oleophobic, and both the phenol resin wettability and the impregnation of the

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